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ABSTRACT

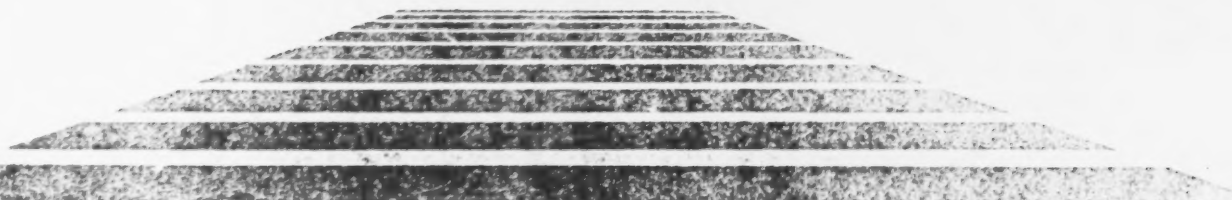
In recent years the use of computers to carry out a range of tasks in the planning and management of educational buildings has proliferated. In June 1988, the Programme on Educational Building arranged a meeting of experts from 13 Organisation for Economic Cooperation and Development (OECD) countries whose objectives were to identify: (1) the extent of computer use in educational property management; (2) the range and nature of different applications; (3) software development trends; and (4) the scope for international cooperation. Since the time of the meeting developments in this field have continued. This report sets out to summarize the state of activity as revealed at the meeting and subsequently. Contents of the report address the scale of the problem; educational, technical, and administrative contexts; computer technology applications for educational buildings; problems and issues; and suggestions for further work. (LMI)

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PROGRAMME ON EDUCATIONAL BUILDINGS

PEB



**COMPUTER TECHNOLOGY
IN THE PLANNING
AND MANAGEMENT
OF EDUCATIONAL BUILDINGS**

AN OVERVIEW
BY
MARTINE BOUSQUET AND BRUNO LEFEVRE

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COMPUTER TECHNOLOGY
IN THE PLANNING AND MANAGEMENT OF EDUCATIONAL BUILDINGS

An overview

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Martine Bousquet and Bruno Lefèvre

Pursuant to article 1 of the Convention signed in Paris on 14th December, 1960, and which came into force on 30th September, 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The Signatories of the Convention on the OECD are Austria, Belgium, Canada, Denmark, France, the Federal Republic of Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries acceded subsequently to this Convention (the dates are those on which the instruments of accession were deposited): Japan (28th April, 1964), Finland (28th January, 1969), Australia (7th June, 1971) and New Zealand (29th May, 1973).

The Socialist Federal Republic of Yugoslavia takes part in certain work of the OECD (agreement of 28th October, 1961).

The Programme on Educational Building (PEB) was established by the Council of the Organisation for Economic Co-operation and Development as from January 1972. Its present mandate expires at the end of 1991.

The main objectives of the Programme are:

- to facilitate the exchange of information and experience on aspects of educational building judged to be important by participating Member countries;
- to promote co-operation between such Member countries regarding the technical bases for improving the quality, speed and cost effectiveness of school construction.

The Programme functions within the Directorate for Social Affairs, Manpower and Education of the Organisation in accordance with the decisions of the Council of the Organisation, under the authority of the Secretary-General. It is directed by a Steering Committee of senior government officials, and financed by participating governments.

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In recent years the use of computers - especially mini- and micro-computers - to carry out a range of tasks in the planning and management of educational buildings has proliferated. In June 1988 an initial meeting of experts from thirteen OECD countries was arranged by the Programme on Educational Building with the following objectives:

- i) to establish in broad terms the extent to which computers are used in educational property management;
- ii) to identify the nature and range of different applications;
- iii) to identify current trends in software development;
- iv) to identify the scope for international co-operation in the dissemination of acquired experience and in joint development work.

Since the time of the meeting developments in this field have continued. The present report sets out to summarise the state of play as revealed at the meeting and subsequently. It is not a record of the meeting as such and the views expressed are those of the authors. They should not be regarded as those of the participants or of the OECD.

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THE SCALE OF THE PROBLEM

1. In all countries participating in PEB, schools constitute the largest share of public buildings.

- In the mid 80's (1984-85), educational capital expenditures - for the most part expenditures on building and equipment - amounted to 14 176 million francs (approx. 1 607 million US\$) in *France*, 6 252 million marks (approx. 2 158 million US\$) in *Germany*, 3 024 million crowns (approx. 360 million US\$) in *Sweden*, 671 million pounds (approx. 883 million US\$) in the *United Kingdom* and 1 415 million florins (approx. 436 million US\$) in the *Netherlands*.

It has been estimated that overall expenditure on educational building in European countries represents an average of 1 per cent of the GNP.

2. In all Northern and Western Europe (with the exception of Ireland), enrolment in primary education dropped significantly during the last decade (1970-1980) due to demographic evolution; by 10.3 per cent in UK, 8.4 per cent in the Netherlands and 6.4 per cent in France. And this trend has continued during the 80's with the consequence that in several countries a number of primary schools have been closed. In the Netherlands, for example, there were 8 725 primary schools in 1981, 8 607 in 1983 and about 8 500 in 1985. In France, the total number of primary schools - public and private - dropped by 2.8 per cent between 1979 and 1982.

3. But this decrease is somewhat compensated by the extension of compulsory education and by the increase in pre- and post-compulsory education. In 1984, 91 per cent of 3-year old French children were enrolled in nursery schools and as more and more mothers find paid employment there is a growing tendency in France to enrol children in pre-elementary schools at the earliest age, sometimes even at 18 months. On the other hand, from 1970 to 1980, enrolment in secondary education rose by 40 per cent in the Netherlands and by 14.2 per cent in France; in addition, there is in all PEB countries an increasing demand for further vocational training for school-leavers, re-training for the unemployed, continuing education for adults, and leisure courses and community cultural activities for all.

4. In the last 8 years or so, due to the general economic situation the trend has been a reduction - sometimes drastic - in educational capital expenditure and the construction of fewer school buildings. This has produced such a severe shortage in many countries, especially in vocational and technical education buildings that in some countries building programmes are expanding again (e.g. the French Ministry of Education has earmarked, in 1989, 12 billion francs for a special "lycées" building programme). The need to construct new educational buildings can be expected to continue for some time.

5. Moreover, in most countries participating in the Programme, the demographic boom of the mid-century along with the extension of compulsory education to lower and, later on, to upper secondary education, resulted in the construction of a great number of schools during the 1945-1980 period. While a few schools were models of pedagogical architecture, many were hastily built with light materials according to antiquated norms; there will be in the near future, and in many cases is already, an enormous demand for maintenance, renovation, alteration, remodelling, and modernization.

- By 1984-86, in the *USA*, the cost of modernization of educational buildings (US\$8 billion) was not much less than that of new construction (US\$10 billion). Similarly, in *Sweden* and in the *United Kingdom* the policy is to renew, rehabilitate and extend rather than to build new schools.

6. Planning, mapping, renovating, and maintaining this huge quantity of educational buildings - at national, provincial and municipal levels - is becoming a more and more complex operation. The introduction of computer technology in school construction and management is no longer an office automation luxury but a practical necessity.

THE EDUCATIONAL CONTEXT

7. Change in educational programmes and methods shows no sign of slackening in pace and will most probably continue to be a further complicating factor.

8. The continued extension of education for young people over 16 has led to a great diversification of studies in the final years of secondary school. A majority of pupils are preparing directly or indirectly for employment and accordingly, a number of non-academic options (25 in Sweden, for instance) have been introduced in the last years of secondary education which were once the preserve of an academic elite; these new professional programmes call for more workshops (e.g. mechanical engineering, chemical engineering, electronics) and add to the shortage already existing in vocational and technical educational facilities; they increase the pressure for modernization of existing educational buildings.

9. Change in instructional methods can also exert an important influence towards more or less radical alteration of traditional classroom layout. The layout needs to be more diversified, with new types of furniture and a large amount of costly equipment (e.g. science laboratories, language laboratories, documentation centres, computers, audio-visual equipment, closed-circuit TV), as computer-assisted learning, group learning, peer-teaching, individual instruction, and experimental science cannot make do with the classical series of identical classrooms on to a corridor. More space and more flexibility are needed.

- In *Norway*, for instance, the intensive use of computers as educational tools for vocational training has notably modified the special requirements for classrooms;
- A *Japanese* study shows that the introduction of CAL requires a classroom area 15 per cent to 25 per cent larger, with special furniture (round tables accommodating 2 to 4 students) and floor arrangement for cabling; while audio-visual classes may require educational space accommodating 150 pupils and more, small group learning necessitates a quantity of "intimate" reduced spaces.

THE TECHNICAL CONTEXT

10. Due to the extension of compulsory education, to enrolment increases in pre- and post-compulsory education, to the diversification of programmes and growing sophistication of methods, the data handled in connection with school building programmes is very large and complex and will become more so. The planning and monitoring of educational buildings has become a gigantic and intricate affair.

Advantages of computer technology for storage, retrieval and analysis of data

- 11.
- i) The contents of thousands of inventory forms filled out by individual schools can be stored on a few hard disks;
 - ii) Retrieval and analysis are much easier and much more speedy as personnel are no longer obliged to search data physically but need only to specify, by means of an application programme, the output required (for instance: number of available study places in a district primary school, number of classrooms of less than 30 m², number of science laboratories per pupil...);
 - iii) Updating inventories is similarly simpler and faster; the user does not have to inspect the whole database in order to see where to insert new data but only needs to give, from his terminal, the necessary instruction;
 - iv) Data can be made much more easily available to many people, either by duplication of disks or tapes or through linking computers over great distances by means, for instance, of the telephone system (modem);
 - v) It has now been demonstrated that computer-stored data are more frequently and more widely utilized than those on manual systems.

Development of computer technology

12. Utilization of large size computers (mainframe computers) for storage and retrieval of educational buildings statistics began in PEB countries in the 1960's and was fairly common in the central services of statistics by the mid 1970's. However, up to 1980, estimates of educational space needs, school-mapping, design, and costing were still usually calculated manually with the help of mini-calculators.

13. Things started to move in the early 1980's when the advent of micro-computers, the development of standard software, such techniques as scanning (for maps and designs) and the progress in telematics allowed, first, a diffusion of computers (in central services, in regional and municipal offices and, finally, in the educational institutions themselves) and, second, an extreme diversification of the tasks executed with computer assistance. By the mid 80's, many planning, research and development services, municipalities, and schools were using mini- and micro-computers for such applications as: preparation of construction norms, cost analysis, optimization of costs, optimization of space use, design, school-mapping, construction monitoring, and accommodation scheduling.

14. For many applications it is possible to purchase ready-made software; but quite a few educational services are, by now, in a position to elaborate their own software exactly suited to their specific needs and circumstances.

- The Central Board of Educational Buildings and Facilities of the *Spanish* Ministry of Education and Science has developed programs on: standard prices to be applied to school construction, standard building details for concrete structures, foundations, mechanical installations, heating plants, typology, size and quality standards for furniture and equipment, etc.;
- The Ministry of Education of the *Netherlands* has developed applications programs for the calculation of expenditures, space requirements and stock control;
- The *Danish* Directorate for Building Projects (Ministry of Education) has developed programs for: recording rented schools and renting conditions, calculating design fees, calculating the expected growth of the building index, controlling accounts of building projects...;
- Grenoble Rectorate (*France*) has prepared programs to support the monitoring and management of food stocks, energy consumption;
- The New South Wales Department of Education (*Australia*) has developed programs for energy management, property financial management, school construction monitoring;
- In the *United Kingdom*, the Architects and Building Branch of the Department of Education and Science, as well as several Local Educational Authorities (LEA) and University Department of Architecture, have developed programs on space utilization, energy management, security, and prediction of space requirements in secondary schools.

15. It has to be noted that the use of micro-computers for the management of educational buildings (and for educational management generally) has been rather late (the mid 80's) by comparison with other sectors and unsystematic. Frequently, computer management has been introduced by municipal or regional authorities not specifically for educational buildings but for municipal (or regional) properties in general. For example:

- The property identification system of the city of Västerås (*Sweden*);
- CAMPUS, a management system developed by the Property Department of Cambridgeshire County Council (*UK*);
- The KIIRE project developed jointly by 16 towns in *Finland* for the maintenance of municipal property.

16. Computerized management of educational buildings was therefore a subset of a larger problem, namely the management of the total public building stock, responsibility for which, in decentralized countries, rests with local authorities. The computer-assisted management of school buildings has been brought about by computer development for other types of buildings (such as public offices or housing) and for other requirements (architecture, surveying). In consequence, the number of software applications developed specifically for use with educational buildings is very limited.

17. Micro-computer management in the field of educational buildings seems to have been initiated at the periphery (in the institutions or municipalities) rather than centrally (at ministry level). This accounts for a somewhat haphazard and scattered development with little standardization and significant duplication at national, regional and, sometimes, local levels.

18. Some degree of 'anarchy' is probably necessary in the first stages of development of an innovation, and allows imagination, inventiveness and boldness. Eventually, however, these limited experiences have to serve as models for all. Such is the case with microcomputer-assisted planning and management of educational buildings: after 6 or 8 years the experiments have been sufficiently numerous and extensive. Participants at the meeting felt that the time had come for more systematization and that the main problems now were networking, hardware compatibility and software standardization.

THE ADMINISTRATIVE CONTEXT

19. The development in the use of computers (mainframe and micro) in planning and management of educational buildings can hardly be understood without reference to the structure of educational administration.

Decentralization and centralization in educational management

20. Some decades ago, there were two clearly distinct types of educational management: centralized and decentralized. France, Spain, Portugal, and Greece were examples of centralization, with everything being decided at the Ministry of Education level or, if not, by the regional representatives of the Ministry. On the contrary, the UK, the Netherlands, and Switzerland were considered typical cases of decentralized systems with total or considerable autonomy on the part of local authorities.

21. Nowadays, the situation is more complex: a trend towards decentralization can be observed in formerly centralized countries whereas some of the previously most decentralized countries are tending to reinforce the responsibilities of central authorities with regard to buildings.

- *France* is engaged, since 1981, in a political and administrative decentralization; 22 regions have been created, each comprising 4 to 5 departments. Regions and departments are run by elected councils (as was already the case for municipalities or "communes") and not, as previously, by civil servants appointed by the central government. Regions are responsible for "lycées" (upper secondary), and departments for "general education colleges" (lower secondary). Municipalities, as before decentralization, are still responsible for nursery and primary schools. Regions and departments may delegate their responsibility for "collèges" and "lycées" buildings to municipalities. Theoretically, the ministry only provides national norms (e.g. minimum area per pupil), guidelines for school plans and advisory services. Buildings plans are prepared at regional, departmental or municipal levels; construction permits are delivered by mayors; all this allows for much more flexibility and adaptation to local conditions.
- In the *United Kingdom*, responsibility for education is shared between the central government, the Local Education Authorities (some 130 LEAs), and the governing and managing boards of the local institutions. A majority of the LEAs executive committees' members and of the institutions' governing or management boards are elected. These elected bodies are responsible, in principle, for the selection and acquisition of sites, choice of architect, and elaboration of architectural programme; there is no standard plan either for extension or rehabilitation. Approval of proposals to open, close or extend schools has to be given by central government; moreover, central government fixes every year a ceiling on the borrowing for capital investment which each LEA may undertake. In other words, local authorities are free to build what they like, as they like, subject to ministerial approval and between prescribed financial limits.
- In the *Netherlands*, there is little difference between public and private schools which are, to a considerable extent, subsidized equally by the state. The initiative to start a school building project belongs to the municipality or school board; but the project must be submitted to the Regional Education Inspector and transmitted to the Ministry for approval and allocation of funds; the Building Departments (there are three of them: for basic, secondary and university education) are in charge of i) the

control and approval of local projects, and ii) school building policy: updating norms of accommodation per level and types of education, updating norms of construction and facilities (cost limits, safety...).

- In Sweden, since 1982, many responsibilities which were previously entrusted to the National Board of Education and to the Counties (24) have been delegated to the 284 municipalities. Architectural briefs are prepared by the municipal school boards. There are no standard plans for school building; but school boards, architects and contractors must comply with safety requirements, heating and ventilation norms, sound insulation, rational use of energy, according to the National Building Regulation. Similarly, school furniture and equipment (purchased by local authorities) must conform to norms published by a National Commission for Standardization.

The Impact of administrative systems on the use of computer technology

22. It is worth noting that the decentralization trend of the early 1980s coincided with the introduction of microcomputers in the management of educational buildings. This does not mean that decentralization is a by-product of microcomputing development, or vice-versa; but it can be inferred that there is some kind of circular relation between the two factors: a microcomputer is a precious tool for decentralized administration and decentralization creates a demand for microcomputers.

23. It can be readily seen also from examples given above that the planning and management of buildings is, in most countries, a more decentralized part of the educational process than, say, curriculum or teachers; training and recruitment. Moreover, many aspects of school building planning and management are not exclusively "educational" and may, therefore, concern other authorities such as: a national statistics service, a national committee on building norms and standardization, regional and municipal property departments, planning authorities, private architects and engineers.

24. Information on educational buildings is necessary for many different purposes: preparation of national statistical reports, reports to international organizations, calculation of governmental support to local education authorities for school maintenance, survey and inventory of public property, school-mapping, research and development, briefing of architects, time-scheduling, and so on. These operations take place at several levels of need, with distinct objectives. This means that requested data are not always exactly the same for all users and cannot be processed in the same way. Therefore, it seems useful to review in some detail existing and/or prospective applications and to see how they are interlinked.

APPLICATIONS OF COMPUTER TECHNOLOGY TO THE PLANNING, DESIGN, CONSTRUCTION AND MANAGEMENT OF EDUCATIONAL BUILDINGS

25. The central difficulty encountered at this point by most authorities is to reconcile the variety of applications and of users with the need to work out an integrated (but not too complicated) information system allowing easy interaction between the different interested parties.

Diversity of applications

26. The particular applications appropriate to an educational system will depend, as we have seen, on the nature of the administration, and the responsibilities of the different partners in it. It was, however, generally agreed by the meeting participants that an ideal school building information system should, where necessary, ensure support to:

- property inventories,
- calculation of state financial support to local educational authorities;
- planning, costing, decision-making (with visualization of alternatives);
- school-mapping (regional or local);
- briefing of, and discussion with, architects and contractors;
- construction and payment scheduling;
- space utilization (accommodation scheduling, time-tabling);
- day-to-day caretaking of buildings (cleaning, safety, security, energy conservation).

27. Up to now, no existing system covers all these applications; but some are already well on the way to doing so.

- The Information Centre for School Building (*Netherlands*), from 1982 to 1988, has developed the following programs on mini- (PDP 11/44) and micro-computers:
 - storing and analysing plans of building stock (on a PDP 11/44) using the first version of the Badger software (see Annex II). The software is used for analysing school-buildings as well as post-offices, prisons, etc.;
 - calculation of space requirements (on a minicomputer);
 - cost planning calculations (on a PC);
 - planning of the housing of all higher vocational education in the Netherlands using stored building and site data (on a minicomputer);
 - development of scenarios for the housing of schools for higher vocational education;

- "reshuffling" the buildings of all the schools in a municipality (Groningen) using stored building and site data (on a minicomputer and PCs);
- calculations of expenditures (on a PC);
- drawings of the layout of all types of classrooms for secondary education (on PCs and workstations).

Diversity of users

28. Potential users of an educational building information system are frequently differentiated according to the level at which they work: institution (principals or headmasters, teachers, caretakers), municipality, regional authority (either purely educational or general), ministry of education, government. Such a classification proves to be more theoretical than practical. While it is true that computer-assisted energy control is carried out at the institution (school) level while the study of alternative solutions for budgetary allocation between technical and general education is a central responsibility; nevertheless, the ministry is very much concerned with the general trends of fuel economics, and teachers, parents and tax-payers may be interested to see why priority has been given this year to the construction of a technical rather than a general education college. Educational building problems, when considered at the level of different authorities may present differences, but these are more of scale than of nature. Stock-taking, costing, matching foreseen enrolment with needed spaces, and decision-making are types of activities which take place at all levels of educational administration but each time at a different scale.

29. The situations reported at the meeting suggest an approach by functions or specialist interests rather than by level of authority. Main functions or specialist interests alluded to during the meeting and in papers received are: decision-making, planning, school-mapping, property surveying, curriculum development, educational technology (both hard and soft), architecture, maintenance engineering, cleaning and caretaking, and financing.

30. At this point, the problem which arises is to decide what sort of information is of interest to all users and what should be reserved for each specific category of specialists. The long-term solution is to have a *core information system* common to all users plus special applications programs. The core system - including the main database and the common processing software (allowing retrieval of the information most frequently requested) - serves as a link between the different groups of users. It is therefore necessary that data stored in the core system be absolutely unambiguous, i.e. that it means the same thing to everyone involved, whatever his level or capacity. Such a core system has been described in the report of a previous PEB experts' meeting on Stock Data Records and Management Systems:

"Functionally, the core should be an intersection through which groups travel in pursuing their specialist activities. It should reflect this by having a heavy bias towards information content that is common to all interests and are frequently referred to and used. Additionally, each specialist application group will hold its own information and carry out its own processes but the core itself should contain carefully selected critical items of information from each field of specialist application."

Which data should be included in the database common to all levels of authority and to the different groups of specialists?

31. There seems to be among specialists a general agreement on the conclusions of the 1985 Meeting as recorded in the above-mentioned report. The list of data recommended in this report was:

i) Site

- code reference
- name of institution on site, address, responsible authority
- ownership
- environment
- area with and without building; legally constructible surface
- site plan

ii) Building

- code reference (linked to site)
- ownership
- use
- type (e.g. main or original, attached, detached, temporary unit)
- age (e.g. 1983, or before 1900, or after 1970...)
- building condition (good, needs repair, needs major repairs, needs replacement)
- fitness to purpose
- area (for the whole building, by floor, by room)

iii) Performance Indicators

- total enrolment
- land area per pupil
- total built area per pupil
- actual enrolment/nominal capacity ratio
- actual hours of use/potential hours of use ratio.

32. Each site, building, floor and room should be identified and referenced through a specific code.

- Taking the example of a computer-based register of a school premises in the city of Västerås, the Swedish National Board of Education stresses the fundamental importance of the *identification code* in an information system:

"It is essential that the code is consistently employed by all users of the information system. It has four components:

- *the basis is the code which identifies the land which makes up the property, and which in Sweden is the joint responsibility of the municipality, the country and the Central Board for Data on property;*
- *the next stage is the assignment of a unique code for each building on the property;*
- *the third stage is a code for each floor of the building;*
- *the final stage is the identification of individual rooms in the building...*

The property identification code must uniquely identify every property, building, floor and room in such a way that similar registers from other municipalities could eventually be linked together on a single system."

33. Drawings, plans, graphics are more and more frequently registered digitally.

- For instance, in the Cambridge Property Utilization System - a management instrument developed in 1986 by the Property Department of Cambridgeshire

County Council (UK) - *"input of text and pictures has been successful, and a method has been developed for altering drawings and maps which have been scanned and input to the computer. A technical difficulty has arisen with the scanning of very large maps which has yet to be resolved. In the meantime, digitised Ordnance Survey maps of the county are becoming available. A scanning facility will continue to be needed in future for inputting local records and maps".* At present the plans of 100 of the County's 400 schools are stored on the graphic module.

34. Stock-taking can be extended to school furniture and equipment (e.g. didactic micro-computers, audio-visual equipment, laboratories, workshop equipment in technical and vocational schools, office equipment).

- In *Spain*, the Central Board of Educational Buildings and Facilities of the Ministry of Education and Science was in the process of creating in 1988 a database on typology, dimensions and quality standards of furniture and equipment.

Recent trends in data collection procedures

35. As indicated previously computer storage of educational building data began in the 1960s; however, for a long time, information was not coded at source but sent in manual form by institution or/and municipality to regional or central authorities for computerization. Important changes are beginning to occur in this field:

In the *United Kingdom*, more and more data is entered directly through the keyboard at source avoiding manipulation of paper records. Moreover, much historical data has already been transferred from paper records to disks. The latest (1989) database management systems are designed to generate all the required output files from one input source. Development of both hardware and software interface facilities on the one hand, and progress in communication system and networking of machines on the other, allows electronic file exchange and reduces the need for separate collection and input.

Utilization of the database

36. Databases can be utilized directly for two traditional types of tasks:

- *inventories* of property, furniture, equipment, fuel and food stocks at all levels;
- *statistics* (either at the national general statistical office or at the ministry of education level) for the preparation of annual statistical reports, government reports, reports to international organizations, educational research; additional standard software permits the calculation of percentages, averages, and growth ratios to compare figures of different years and regions and to translate figures into graphics.

37. These tasks have been for a long time, together with the calculation of salaries, the major, if not the only, computer applications in the education field. All other applications ask for specific computer programs and, probably, additional data files. They can be classified in seven groups.

i) Applications for calculation and payment of central government contributions to regional and municipal authorities (or to private institutions)

38. These are among the oldest and the most widely utilized computer applications in educational management. Depending on the management system in use, central government contribution can be:

- allocated directly from central authorities to municipalities (or institutions) or sent to the region for redistribution;
- global (for all educational expenditures) or specific (for salaries, maintenance, modernization, new building...);
- An example of the direct procedure, specifically for maintenance: In *Finland*, the 461 municipalities (94 of them are towns) regularly send manual information about educational property to the National Board of General Education in Helsinki. The National Board has to calculate from this information the amount of the state contribution due to each municipality for the maintenance and management of school buildings. The calculation of payment is very complicated as it varies according to the density of inhabitants and the expenditure classification of the municipality; in consequence, the National Board has, for years, used computers for these calculations. Information is stored in Helsinki and sent, via modem, to the State Computer Centre in Tampere where the mainframe is situated. The programming language is Fortran. Program generators are used to make reports and statistics.

39. Calculation and payment of government contribution to local authorities necessitates:

- supplementary datafiles, such as list, addresses and accounts of local authorities, classification of regions, municipalities and institutions (for rate of support according to location, type, etc...), previous payments made (for checking), calendar of payments...
- an appropriate calculation program.

ii) Applications related to planning and decision-making

40. The forecasting of educational building needs is dominated by problems of enrolment, number of teachers (for student/teacher ratio), curricula and pedagogical methods, and the financial situation. Therefore, it can hardly be conceived separately from general educational planning. This, in turn, asks for many additional data (not foreseen in the common database presented above) and a number of specific computer programs.

- a) Students: data on present enrolment (necessary for calculating actual use of space and the share of state support) is not sufficient for planning which needs short and medium term projections of students' flows as well (according to demographic trends); moreover, planning of educational buildings - as well as teacher training - require some sort of information on how many students of each year group will, according to economic estimates, seek entrance in each branch of the educational system; all this implies taking stock of a large number of demographic and economic data as well as long and often complex calculations for which the computer has become an indispensable tool.
- b) Teaching staff: Data on the number of teachers required and available in each discipline is necessary for i) programming needed space in teacher training colleges and ii) setting norms on student/teacher ratios.

- c) Legal norms: m2 and m3 of classroom per pupil; recreation area per pupil; safety requirements, heating, access for disabled, lavatories; students/teacher ratio (on which depends the size of classrooms); ergonomic and pedagogical norms of furniture according to the students' age; computer may be used to apply mathematical methods of analysis to anthropometric and pedagogical data with a view to optimizing "learning comfort".
- d) Structures and programmes: for instance, overall number of teaching hours (per day, week, year) will show the minimum space requirements for educational purposes and, at the same time, the availability of the building for other purposes such as evening or holiday courses. The number of experimental science teaching hours or of practical industrial work will indicate the needs for laboratories or workshops, etc.
- e) Pedagogical aspects: Methods of education have a strong influence on space requirements. For instance, group-learning, peer-teaching, individual contract-based learning, computer-assisted learning, tele- or video classes evidently need different space arrangement.
- f) School buildings cannot be transformed, rationalised or rearranged every year; therefore, planners need to know: not only what is the pedagogical situation now but also what it will be, or at least could be, during the span of life of the building; this means that short term projections are not sufficient and that computer applications should include support to prospective research for the sake of caution and flexibility, if not for precise prediction.
- g) Cost calculations: Referring exclusively to educational building costs, these involve:
- estimation of costs. In the absence of detailed architectural plans for all the schools to be built in the country within, say, 5 years, unit costs must be assessed on the basis of various indicators. For instance, it is known, from past building programmes, what has been the cost per pupil place in schools of different types (primary, vocational, technical...) and enrolment sizes in various geographical locations; past costs, properly adjusted to take inflation and trends of building cost indexes into account, can be utilized as indicators for updated or future unit costs. Computers are well suited for tackling such statistical and mathematical problems;
 - use of computers for storage of cost data such as:
 - average costs (for each year);
 - evolution of historical costs (in graphical form), projections of future costs;
 - cost limits (norms);
 - estimated costs (for planning);
 - inventory of financing sources.
- h) Computer technology can be of great assistance in the most difficult part of the planning process, i.e. decision-making:
- the central problem of education building planning (and of educational planning at large) is to provide the most efficient physical facilities at the

minimum cost. This type of optimization problem is part of a technique known as operational research or system analysis. Due to the many factors involved (expected outcome, curriculum, methods, size of learning groups, utilization of spaces, building methods and materials... and to the large amount of numerical manipulations involved) these problems can hardly be tackled without a computer. They necessitate sophisticated software;

- moreover, thanks to computerized models, it is possible nowadays for deciders to visualize easily and quickly the consequences of alternative decisions or the projections in the future of one or another demographical or economical hypothesis. This technique has been tentatively in use since the early 60s (e.g. the Asian model prepared by Unesco Secretariat in 1964);
- computers can also be utilized in association with role-playing and other simulation exercises conceived for identifying human reactions (support or resistance) provoked by an educational plan. These computer-assisted simulations are not unlike the "enterprises games" which have, by now, become of frequent use. This technique is very useful, for instance, for foreseeing and weighing the probable reactions to a school location plan.

III) *Applications related to school mapping*

41. School-mapping, i.e. the geographical location of the different types of schools is the last stage of the planning process. It can be executed either at national, regional or municipal levels according to the type of schools.

42. Two decades ago, school-mapping was a speciality of centralized administration (e.g. France, Spain), while it was not generally practised in decentralized systems (e.g. UK, Netherlands). Nowadays, in view of the extreme diversification of secondary schools (see above) and of the concentration of pupils of different schools into one, due to demographic changes and/or population shifts, the practice is extending to traditionally decentralized countries.

In the *Netherlands*, for instance, where no school-mapping was previously available, the Ministry of Education and Science is in the process of computerizing educational buildings stock and considering the redistribution of educational institutions, particularly at the secondary level (for instance the new 3-year middle level college), but also, the possibility of converting closed-down primary schools into secondary-level institutions.

43. School-mapping does not only cover the location of new schools but also, more and more, the extension, modification, and modernization of existing ones. In the *Netherlands*, experts consider that "reshuffling" of the building stock will focus *"on the use of computer applications in connection with the alteration and re-modelling of existing buildings as opposed to new-built work"*.

44. A further consequence of decentralization is the use of school buildings as "community centres"; in many cases, mapping may therefore have to consider not only the need for teaching space for youth during school hours but also for libraries, auditoria, etc., for continuing education.

45. Manual techniques for school-mapping had already reached a high level of efficiency in the 50s (e.g. the technique of using overlays to enable the visualization of the situation before and after implementation of the plan, and to compare various hypotheses). It is now possible, by using scanners, to digitise data from existing maps and to easily introduce changes in the schools' location as desired (cf. CAMPUS programme of Cambridgeshire County Council - see above); this, added to the increased

quantity of factors, makes the use of computer technology desirable and possible for solving the many optimization problems offered by school-mapping.

- In a given catchment area, and considering all factors involved (transportation costs, scale economies, adult education needs, possibilities of community support) is it more effective to build a few large schools or a greater number of smaller schools?
- Considering on the one hand, the age and state of existing facilities and, on the other, prospects of future utilization, is it more profitable to extend and modernize or to build new?

46. School-mapping is a tool for deciding on the location of schools; such decisions are not purely technical but often have highly political, and even polemical implications. Each municipality is liable to fight for keeping its school; economies of scale offered by large schools are often balanced by community support for small village schools; sometimes, the redistribution of primary schools implies, as in the Netherlands, the merging of public and private schools (a decision to which parents and school boards of the latter are usually strongly opposed to). Computer-assisted forecasting techniques are highly advisable for assessing potential opposition.

(v) Applications related to research and development in educational building - norms and standards.

47. Research and development in educational building design, and the setting of norms and standards may be conducted by:

- a) a special department in the Ministry of Education (e.g. the Architects and Building Branch of the Department of Education and Science in the United Kingdom, the Directorate for Building of the Danish Ministry of Education, the Central Board of Educational Buildings and Facilities of the Spanish Ministry of Education and Science...);
- b) central and regional offices of the Ministry of Construction (France), National Commission on Building Norms and Standards (Sweden);
- c) Private foundations receiving fixed subsidies from the government and working on contracts with local authorities such as the Information Centre for Schoolbuilding (ICS), (Netherlands).

48. R & D activities include:

- experimental and innovative design;
- evaluation of plans (e.g. prediction of thermal behaviour of the building), evaluation of prototypes;
- space planning (e.g. optimization of movement inside an educational building with a minimum waste of space); queue problems (e.g. for determining the necessary number of toilets, canteen seats, work-stations...);
- analysis and optimization of construction costs, (application of system analysis to educational building planning);
- setting norms for: area per student, safety, daylight (e.g. in Sweden), sound and temperature insulation, ventilation; specifications of building materials...

- fixing construction cost limits.

49. The responsibility of R & D services may also include setting standards for school furniture, and evaluation of furniture designs produced by private manufacturers.

v) *Briefing the architect*

50. Three decades ago there were a few constant and universal models of school spaces. To-day, with administrative decentralization and rapid pedagogical change, the building of each new school tends to be a distinct affair and, in consequence, preparation of design guidelines is becoming increasingly important and complex for renovation as well as for new construction.

51. It is no longer sufficient simply to inform the architect about the size and location of the school, the level and type of education, and the norms to be followed. Architects must also be familiar with what will go on during the day in the building he has to design, what each small group of pupils will be doing, what is likely to happen in the building after the pupils leave, what future users (administrators, teachers and, if not pupils, their parents) may insist on having and what they will not want. This implies a detailed analysis of use and a great deal of consultation.

- Consultation. Preliminary meetings of all interested parties are certainly necessary but not sufficient. The architects must be able during all the design process to consult quickly one partner or another on specific details. Standard telematic applications exist which can considerably facilitate constant contacts (teletransmission of plans either on paper or on screen, computer-assisted conferencing, opinion pooling, etc...).
- Preliminary brief designs. Computer-assisted design (CAD) has been successfully utilized by architects since the early 1980s. CAD does not mean the automation of the entire design process; it only aims at saving the repeated redrafting of the same elements (a door, a window, a standard size room, stairs, toilets...). Consequently, CAD has become a common tool for architects for the preparation of "production documents".

52. The present report does not deal in detail with CAD (a concern not purely of educational building but of architecture in general) but it is, nevertheless, worth pointing out its value for the consultation stages of the design. Combined or not with telematics, simple CAD programs allow the architect to exchange points of view with users on the basis of plans and drawings, either physically or at a distance. This "graphical dialogue" is specially useful for the extension, alteration or modernization of existing buildings; when discussing space remodelling or new facilities location, CAD techniques help illustrate what is said and to reach non-ambiguous understanding.

vi) *Applications related to educational building management at central, regional or municipal level*

53. This section considers computer applications for:

- the monitoring of the educational building plan (usually at central or regional level);
- the scheduling and monitoring of construction projects (usually at municipal or regional level);
- the control of data collection;

- the control of data reliability.

54. Monitoring the plan. Computer technology can supply educational authorities with an "instrument panel" allowing them to follow exactly the implementation of a school construction plan. There is naturally not such a thing as an automatic piloting of the plan, but the computer can deliver automatically, at fixed intervals, written reports on progress (number of plans approved, of sites opened, or work completed). It gives to officials in charge the possibility of visualising on their screen, upon request, the situation at any given moment, by a graphic presentation (with colour indicators for caution and danger). It allows them to obtain a list of the projects which have been delayed and, perhaps, to ask - through the computer - the reason for the delays and to receive an answer immediately. It represents, therefore, a formidable tool of administrative control which, when something is not going according to schedule, enables the required measures to be taken in good time.

55. The same principles apply to the details of any single construction project. Traditionally, construction works have been a pioneer field for scheduling and monitoring techniques:

- bar-chart indicating, against a time-scale, the period during which each activity of the construction process is supposed to take place;
- relevance tree describing the sequence in which activities must be performed;
- critical path methods (e.g. Program Evaluation and Review Technique, "PERT") which enable the identification of activities which must be completed on time to avoid delaying the project.

56. Such methods serve both as programming aids (indicating financial, material and human resources to be made available at each stage of the project) and an instrument panel (enabling checks on whether the project is progressing satisfactorily or not, and subsequently identifying any follow-up action to be taken. The use of a sophisticated method such as PERT is considerably facilitated by computer technology. The computer is particularly useful in the monitoring phase for regular up-dating of the construction programme which, if done by manual methods, is both difficult and very time-consuming. There is, now, standard software for project monitoring.

57. Computers also facilitate data collecting and up-dating operations; for instance, they can remind concerned authorities when each phase of data collection should start, check whether answers have been entered in due time and send the necessary reminders automatically.

58. Remote inspection. Finally, computer technology may assist in the vital task of ensuring that the information within the system is both valid and up-to-date. To this effect, programs could be devised for comparing present with past data, data from one municipality with those from another and, generally, for evaluating the coherence of the information received. Deviations from normal would be graphically pointed out, suggesting further analysis and, if necessary, inspection on the spot.

vii) Applications related to educational building management at institutional level

59. At this level, the main applications include: space management, inventories, environmental monitoring, day-to-day maintenance, repairs.

60. Computer-assisted time-tabling. Accommodating spaces (and hours) for a number of learning groups with different curricula and, possibly, different enrolments, taking into account the needs for special spaces (such as science or language laboratories, computer rooms, documentation room, gymnasium), the availability and wishes of professors, pedagogical constraints (students' tiredness at

different times of the day) etc... is a tedious and time-consuming process for school principals, when carried out with pen and paper. It can be considerably facilitated and speeded up when computer-assisted; moreover changes in computerized timetables are made much more easily than those in manually-generated ones. There is in several countries a rapidly increasing use of programs for preparing and reworking timetables; some are commercial software packages, others have been developed by institutions' staff.

- Among commercial packages, one example is pc-UNTIS, a "user friendly" program developed for microcomputers by an *Austrian* firm, available in English, French, Finnish, German, Italian and Swedish versions and distributed all over Europe. The user has to input a certain amount of master data about teachers, classes, subjects and rooms. This data would tell the computer, for example, how many teaching periods there are in the school week, the sizes of rooms and which ones are available when. Then the computer has to be told what other conditions there are on timetabling - for example that teacher A is unavailable on Tuesday mornings, that younger classes should only have afternoon lessons two days a week, or that history should be taught in room B whenever possible. To each of these conditions can be attached a degree of importance. The program can then be set in motion to calculate the timetable which best meets all these conditions. This can be done on several different levels, on a scale from 1 to 9. For example the compilation of a timetable for a school having thirty classes takes about twenty minutes at level 3; a more intense optimization can triple the time needed but will produce a significantly improved result, especially where the structure of the timetable is complicated.

61. Applications designed to prepare timetables can also assist in managing space utilization for cultural and educational activities for the wider community in the evening or during holidays.

62. At this level there is also a need for inventories of furniture, equipment, documentation, vehicles, fuel and food stocks.

63. Environmental monitoring. For quite a long time, computers have been used for the management of energy (control of boilers and adjustment of room temperature), for safety (fire and smoke alarms) and security (more and more necessary with costly equipment such as microcomputers, TV sets, electronic typewriters...).

- One even speaks nowadays of "intelligent" buildings, equipped with general electronic control of lighting, heating, ventilation, lift installation, period bells, fire detectors, burglar alarms. Computer control and monitoring of school buildings has been in use in a number of primary and secondary schools in the *Australian* Capital Territory since 1981. In *France*, the so-called "lycée of the future", at Jaunay-Clan near Poitiers, offers an example of such "centralized technical management".

64. Finally, there are many standard computer programs for scheduling and monitoring day-to-day maintenance and repairs. Such programs assist in keeping record of past events (when was the boiler last changed, when was a part of the roof replaced?), by indicating the calendar of planned maintenance (e.g. of plumbing, swimming pool...) and of foreseen work (e.g. repainting of first floor).

PROBLEMS AND ISSUES

From scattered experiments to systematic computer-assisted management (CAM)

65. Until recently, the use of microcomputers in the management of educational buildings was dependent on individual initiatives and, consequently, the computer was still a kind of ornament to the traditional manual administration, the "icing on the cake".

66. That is no longer quite true. During the last two years, there has been in several countries "a marked increase in the number of people gaining computer knowledge and keyboard skills" (UK). At the same time, networking is developing rapidly within administrative units (e.g. the Danish Direction for Building at the Ministry of Education) or among all the institutions of an educational district (e.g. the Schools Authority of the Australian Capital Territory). Consequently, educational building data is now beginning to be entered directly through the keyboard at source (UK, ACT), which is a decisive step in the collection/storage process. Such occurrences are certainly still exceptional; but exceptions are becoming more and more numerous and the process may already be considered as irreversible.

67. In many countries, the experimental phase has either ended or is ending. The next step is to generalize computer use at all levels and in all aspects of educational building planning, design and management. An administrative organisation is a whole: it would not be very beneficial to pursue computer-assisted management, say at regional level, if it only existed sporadically at municipality or institutional levels; neither can one imagine a computer-assisted educational system if municipalities, regions and the whole national administration were not managed similarly.

68. Decision-makers at all levels are well aware that, one day or the other, it will be necessary to switch from a manual to a computer-assisted management system; but they, understandably, hesitate when facing the magnitude of the task and the foreseeable problems entailed.

Human problems

69. The introduction of computers in educational management has, in the past, met with considerable and understandable *suspicion, inertia and resistance* from staff, especially from the older members. The situation is improving. In most OECD countries, a sizeable percentage of officials and clerks under 40 are by now computer literate... including senior staff who, previously, were often reluctant to get "hands-on experience". Staff opposed to computer use have become a minority.

70. Training is important.

- "With regard to the training of personnel", writes a British expert, "the initial requirement for basic knowledge of machine operation, keyboard control and specific application processes has been largely met and the greater demand now is for user training when new software applications and systems are introduced or, more occasionally, new hardware is purchased. There is still a reluctance to use manuals and adopt self-teach methods but the cascade principle of sharing knowledge and experience appears to operate of its own volition. I suspect that some demands for training made in the past have masked fear or inertia". (UK).
- In Denmark, the Directorate for Building has created an informal task force which, since the beginning of computer implementation, has tried to involve all new users

as soon as they were equipped with a terminal or even before. "The aim is to make the coming users familiar with the new techniques as well as to enable them to develop and maintain their own programs. This way, the knowledge and interest for computers have quickly spread all over the administration, especially among clerks and junior officers".

71. In some OECD countries, a more difficult problem for CAM, as for CAL, is the recruitment of top level computer technology specialists (e.g. programmers) at the salary level offered by public administration.

Cost problems

72. Cost is generally considered by specialists as the main limiting factor to a rapid implementation of computer-assisted management. Switching from manual to computer-assisted management entails a quantity of time-consuming operations (e.g. transferring all existing data from paper to computer records) and, therefore, is very expensive.

73. The price of *hardware* has dropped very rapidly but at the same time, the range and complexity of communication peripherals is continuously increasing; computer technology leads to telematic technology; equipment costs therefore remain high.

74. The cost of *software* is directly related to the number of man-hours devoted to its development. As a result, "off-the-peg" commercial software is generally cheaper than custom-written software since its development costs are spread over a greater number of users.

75. It is true that in the long run computer-assisted management will save time, and consequently money; in the meantime, as long as the system is not yet run in, computer-assisted management means extra-expenditures; and many municipalities or ministries faced with this fact hesitate to invest and still choose to "wait and see".

Operational problems

76. *Creating a database*

- School building management is a subset of educational management, architecture and construction, and municipal, regional, national management. This entanglement of points of view and responsibilities complicates the choice of data;
- There must be complete agreement of all interested parties on definitions, standards and coding; this is considered a priority task;
- Data must be easily readable at all levels (summaries, graphics...).

77. *Updating* is, according to most specialists, one of the most difficult and crucial issues; it should be done automatically at the source on a daily or weekly basis; this requires a strict discipline.

78. *Errors* in a computer system are, perhaps, likely to be more easily hidden; somebody must therefore control constantly the accuracy of stored data; elaboration of software to assist in this type of control appears to be a priority.

79. A computer-managed database runs the risk of becoming an *anonymous* and, therefore, irresponsible affair; in consequence, all entries should be signed; this is achieved through the use of a secret personal code, for instance.

Technical problems

80. *Compatibility* seems to be the main problem when, as it is often the case in most OECD countries, equipment has not been planned as a whole but has been done piecemeal and, often, by individual users. This may be a hindrance to networking.

81. Lack of hardware standardization introduces the problem of software transportability. Software written for implementation on one type of computer will not necessarily run on a machine produced by another manufacturer; furthermore, machines produced by the same manufacturer are not always compatible.

82. The *evaluation* of software is essential. The variety of software offered on the market makes choice very time-consuming. Assessment from the available documentation is never completely sure; there is no substitute for a trial use made with reference to the task to be performed.

83. Constantly *changing* technology may be one of the factors which leads decision-makers to a "wait and see" attitude.

Are the results worth the effort?

84. The point is not to persuade decision-makers but to present them with all the elements of decision. Objective *evaluation* of the performance of computer-assisted management in other countries would be useful. One knows more or less what is being done elsewhere but seldom how it compares with previous manual management and what were the difficulties encountered and the costs.

85. *Simulation* of implementation of computer-assisted planning and management would help to visualize problems and alternative solutions.

SUGGESTIONS FOR FURTHER WORK

86. There is a need for *information exchange*. PEB should

- develop a clearing-house activity for exchanging experience on new methods of educational building management and planning, including the use of computers;
- encourage the production of case studies on the development of computer-assisted management of school buildings with detailed cost and technical data: description of the main difficulties encountered as well as an evaluation of results; such case studies were deemed very useful to the specialists of other countries;
- investigate the possibilities offered by telematics for facilitating the exchange of information.

87. There is a need for *standardization*:

- of concepts used in school building planning and design;
- of the codification of data.

88. One of the priorities is the codification and agreement of local, national and international standards to permit the extension of *networking and interconnectivity of hardware* from different manufacturers.

89. It would be extremely useful to have at disposal a *reference file of available software and applications*. This could take the form of an annotated bibliography to which would be added a series of evaluations made by the professional press or by members of the Programme.

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